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NUMBER 12.

BULLETIN 36.

West Virginia Agricultural Experiment Station.

MORGANTOWN, W. VA.

BLACK HOLES IN WOOD.



February, 1894.



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Agricultural Experiment Station

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No 12

ENTOMOLOGICAL DEPARTMENT.

VII Injurious and Other Insects of West Virginia

5 Forest and Shade Tree Insects



BLACK HOLES IN WOOD.

BY A. D. HOPKINS,
Morgantown, West Virginia

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All of the Figures in this Bulletin are original.

*Figs. 1-26 are in Bulletin 35,

†Plate I is in Bulletin 16: first bulletin on Forest and Shade Tree Insects.

BLACK HOLES IN WOOD.

BY A. D. HOPKINS.

Certain characteristic, black holes in the wood of oak, poplar, beech, birch, etc., are of such common occurrence that every one who has had much occasion to handle these woods, is no doubt familiar with the defects. They usually occur in the best part of the wood either one in a place or two, or more in a row, and are always accompanied by discolored patches or streaks, as shown in the illustrations on title page.

This defect is so prevalent in white oak and certain other oaks, that it is often difficult to find a tree the wood of which is entirely free from it. In looking over a large lot of ordinary oak lumber, one can scarcely find a piece which does not show one or more of the characteristic, black holes with their accompanying discolored streaks.

In Yellow Poplar (Tulip Tree or White Wood) the same kind of defects are found, but not so commonly as in oak. When they do occur, however, in this timber the resulting damage is far greater than in oak. What is locally known as "Calico Poplar," a common and serious defect in poplar lumber from certain localities is the result of the presence of these holes. I have also observed the same trouble in beech, birch, basswood, maple and elm in this State, and elm and oak from Michigan.

The Cause Heretofore Unknown.

The real cause of this defect has, I have every reason to believe, been heretofore unknown, or at least nothing so far as I can learn has ever been published on the subject. The general supposition among those who are most familiar with it is that the holes are produced by worms; hence they are almost universally called worm holes.

My earliest recollection of insect injuries to timber is that of these black holes in wood. I remember when a boy watching the operation of riving clapboards and staves, that many of the pieces were thrown aside on account of "worm holes," as they were then called. Since I have been studying the habits of wood infesting insects, in recent years, I have noted the peculiar character of this injury, and the effect on the adjoining wood. While I was convinced that the holes were produced by a beetle belonging to a class of insects known as timber beetles, I failed until recently to meet with the culprit within its burrows. Hence, the species to blame for the trouble, and why the holes occurred so deep in the heart-wood, had until then been a mystery. The fact that some of the holes were found near the heart-wood of large trees indicated that the species causing the trouble must have different habits from any of the timber beetles known to me. The mystery regarding the cause of these peculiar black holes, and why they occurred in the best part of the tree was made plain enough when, on October 7, 1893, while conducting investigations in Randolph county, West Virginia, I discovered the insect within its burrows in the sap-wood

of living vigorous white oak and chestnut-oak trees. The discovery led to further research regarding the habits of the species, the character of the injuries, etc., resulting in the development of a number of new and very interesting facts. Among them, we may mention the following:

That species of the family, to which this one belongs, attack vigorous healthy trees has been doubted by some good authorities on entomological questions. I find that this species will enter the wood of the most vigorous trees for the purpose of excavating galleries and brood chambers, and that a brood of young will develop in the same, while the tree is in a vigorous growing condition. This fact, together with my observation on the habits of the destructive Pine Bark Beetle, which belongs to the same family, is conclusive evidence to me, at least, that two species, one a bark beetle, the other a timber beetle, will attack and breed in vigorous growing trees, and that they appear to do so through preference.

Another interesting fact regarding the black holes and the accompanying stains in the wood is, that by counting the annual rings formed over them we are enabled, perhaps, to record the earliest date of insect injuries in America. I have found black holes in oak logs that I am able to state, with a positive degree of accuracy, were excavated in 1753. I have also found the characteristic stains in the end of yellow poplar logs dating back to 1693 in one log, and to 1479 in another, the latter having been made 13 years before Columbus discovered America.

I have evidence that the insect recently discovered, or one having the same habits, was not uncommon at these early dates, and that it has been more or less common in our forests up to the present time. Yet the insect that we have found to be the cause of this peculiar defect is a new or undescribed species.

A New or Undescribed Species.



Fig. 27.—*The Columbian Timber Beetle.*
Enlarged and natural size; shining
black, with rust-colored legs
and antennae.

I have given the common name, Columbian Timber Beetle and the scientific name *Carthylus Columbianus* to this interesting new species, and will here give a popular description of it.* The adult

*A technical description of this species was read before the Entomological Society of Washington, D. C., on Dec. 7th, 1893, and will be published in the Proceedings of the Society,

Figs. 27 and 28, is $\frac{1}{6}$ of an inch long and 1-16 of an inch wide. The body is shining black above and below, with rust-colored legs and antennae (the small objects projecting from the side of the head). Like most species to which it belongs (See Figs. 8, 10, 12 and 14, Bulletin 35), its body is divided across the middle, thus having the appearance of possessing a head nearly or quite as large as the remainder of the body. The head, however, is not observed from above, but is plainly visible from the sides, as in Fig. 28. Thus it will be seen that this species, like all other insects has its body divided into three, more or less distinct parts. First, the head or front portion. Second, the thorax or middle portion. Third, the abdomen.



Fig. 28.—*The Columbian Timber Beetle*. A. Side view of male enlarged; head concave, antennae larger than in female. B. Head and thorax of female; side view enlarged; head convex.

head of the male is concave, and covered with short, stiff, brownish hair, while the head of the female is convex and covered with slight indentations, or punctures. The upper surface of the thorax in front of the middle is covered with rough or wavy elevations, while the surface back of the middle is smooth, shining, and covered with small punctures. The wing-covers (*elytra*), which encase the upper portion of the abdomen, are covered with small punctures, but not arranged in rows, as is commonly the case with species of this class of beetles. The wing-covers are also smooth and shining except near the ends where they slope down from the back, called the declivity of the elytra. Here the surface is slightly roughened by small tubercles, and thinly covered with long hairs.

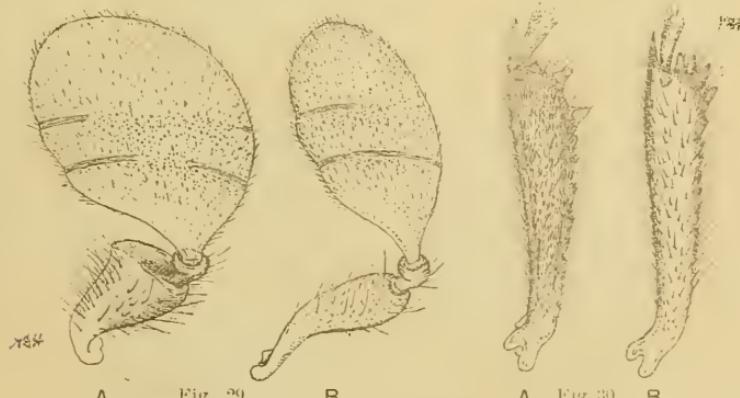


Fig. 29.—Antennae of *Columbian Timber Beetle* as they appear under the microscope. A, antenna of male; B, antenna of female.

Fig. 30.—Middle portion of legs, *tibia*. A, tibia of middle leg; B, tibia of front leg.

In describing new species, it is usually necessary to dissect some of the individuals, and to study, by the aid of the microscope, certain parts of their anatomy; as, for instance, the antennae, or "feelers," Fig. 29. Also the feet and other parts of the front, middle

and hind legs. In every species, differences are found in the structure and markings of certain parts, which enable us to say that they are different or distinct from any other species.

The large size and peculiar form of the antennae of this species, together with certain other distinctive characters, are only possessed by three known North American species; two others besides this one. This species differs from the other two in its larger size, finely punctured head of the female, small tubercles on the declivity of the wing-covers, and in having four spines near the tip of the tibia of the middle and hind legs, Fig. 30, A.

Classification.—The Columbian Timber Beetle belongs to an order of insects called *Coleoptera*. This order includes all of the kinds of insects known as beetles, which have hard wing cases usually extending to the tip of the abdomen. The order is separating into a large number of families, each family being made up of groups of genera having some marked characteristics common to all the species included. This species belongs to the family *Scolytidae*, which includes, in this country, nearly 200 known species, Figs. 8, 10, 12, 14 and 26, being characteristic representatives of the family. It belongs to the genus *Corthylus*, which until recently contained but one species. The family *Scolytidae* includes bark beetles which infest the bark of trees; timber beetles which inhabit the wood; twig beetles which breed in the terminal twigs, and root beetles which bore into and breed in the roots of certain plants.

Habits of the Columbian Timber Beetle.

Like most other timber beetles, this one, in excavating its galleries and brood chambers (the black holes), does not extend them beyond the sap-wood, and from what I have observed, it would appear that this species attacks only the healthy wood of living trees. Of the large number of their galleries examined during the investi-

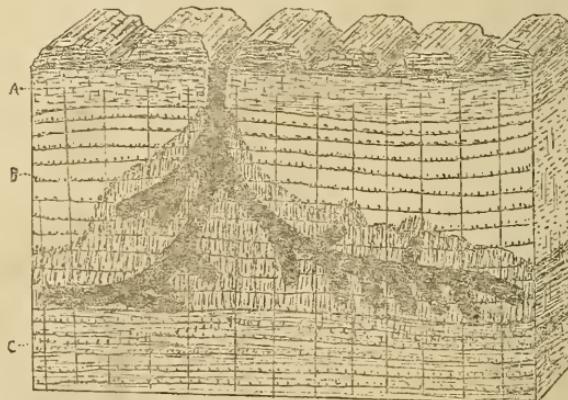


Fig. 31.—Galleries and brood chambers of the Columbian Timber Beetle, as they occur in oak. Natural size, showing the position and character of the branching galleries, brood chambers, and end view of the surrounding stain A, inner bark; B, sap-wood; C, heart-wood.

gation, not one was found near an injury to the bark or wood. The parent beetles select the crevices and thinnest places in the bark, then bore through it and directly into the sap-wood for a short distance. Then one or more branching galleries are extended in different directions, but usually to the left or right diagonally across the grain of the wood, as shown in Fig. 31.

In oak, portions of the branching galleries often extend almost or quite parallel with the growth or layers of wood. There are usually from two to three of these branching galleries, their angle to the main entrance depending largely upon the thickness of the sap-wood of the tree attacked. In the oak, the sap-wood is usually thin, often not over one inch in thickness. Under such conditions, the galleries are like those shown in Fig. 31. When the sap-wood is thick, say two or three inches, the insect often extends the main gallery directly across the growths towards the heart until they near the heart-wood. The branches in this case are more or

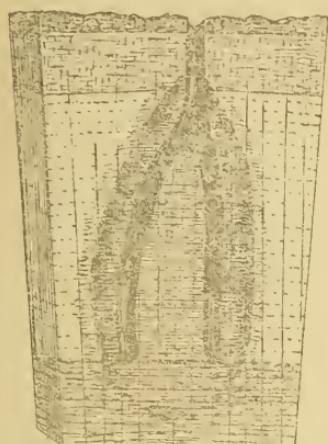


Fig. 31.—*Main and branching gallery in Beech*, showing position of galleries and character of cross section of stain, shown in Fig. 32.

less parallel with the main gallery, as in oak, extend as a rule sidewise from the main gallery, but in beech, tulip, etc., they usually extend up and down, nearly parallel with the grain of the wood. These side chambers serve as kind of cradles, or nursery chambers in which the young remain from the time they hatch until they are adults.

It appears that they are excavated by the parent and that a single egg is deposited in each. The eggs soon hatch into minute footless grubs, which evidently feed upon the secretions from the wood or the sap as it flows into their chambers.

As this insect has only recently been discovered, it has not been possible as yet to ascertain the time it takes for a brood to develop, or the number of broods occurring in one year. Judging, however, from what is known of the life history of species nearly related to this one, it would appear that there is not more than one or at most two broods in one season. It appears that the broods developing in the fall remain in the brood chambers or galleries until

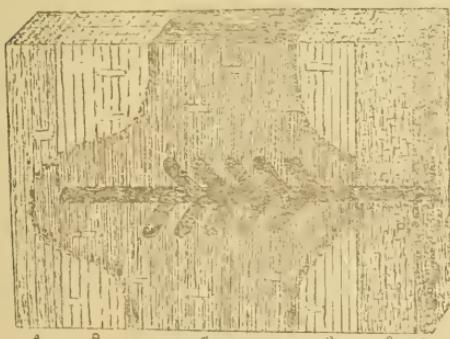


Fig. 32.—*Side view of main gallery in Fig. 31*: showing position of brood chambers as they occur in Beech. A, heart-wood; B, sap wood; C, stain, side view; D, inner bark; E, outer bark.

As this insect has only recently been discovered, it has not been possible as yet to ascertain the time it takes for a brood to develop, or the number of broods occurring in one year. Judging, however, from what is known of the life history of species nearly related to this one, it would appear that there is not more than one or at most two broods in one season. It appears that the broods developing in the fall remain in the brood chambers or galleries until

the following spring, when they proceed to make new galleries either in the same tree or in others near by.

Character of the Injury.

It has been demonstrated that the insects infest only the sap-wood, but it does not follow that the injuries will not occur in heart-wood; in fact, they are found to be most common in the latter. The mysterious occurrence of these injuries near the heart and at different points from there to the sap-wood in large trees was clearly explained when I discovered that as the injury is made, in the healthy growing sap-wood, the annual growths or rings cover over, and seal up the entrance to the old galleries the year after they are made. Thus, the entrance to galleries made in the sap-wood of a small tree, say six or eight inches in diameter, will the following year be covered over by an annual growth of wood. In one hundred years, if the tree lives, 100 rings will have formed over the entrance. If the tree attains a diameter of say four or five feet, and the annual rings represent a growth of four or five hundred years, the first injury will occur in the heart-wood near the heart of the tree. Subsequent injuries from the same cause will be distributed through the wood at different points between the first injury and the outer sap-wood, the year in which each attack was made being accurately recorded by the annual growths formed over the original entrance. Fig. 34.

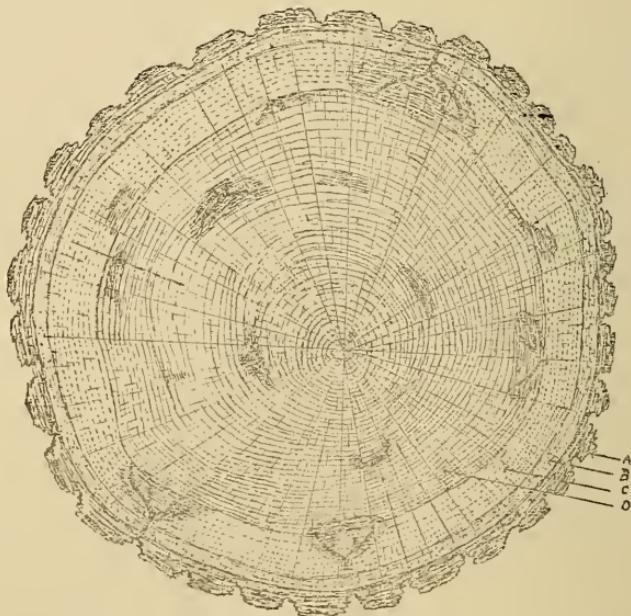


Fig. 34.—End of Log, showing galleries made by the Columbian Timber Beetle, and the stains as they appear at different depths in the wood; also the four distinct parts of the trunk of a tree: A, outer dead bark; B, inner living bark; C, sap-wood; D, heart-wood.

It will be seen by referring to Fig. 35 that the new growths as they form over the entrance, will be somewhat affected for thirty or forty years after the galleries are excavated, thus producing a curled or wavy appearance in the surface of the wood above the entrance, until the growths become normal, when all traces of the injury are obliterated in the surface of the sapwood. In some kinds of trees, however, the wound in the bark will remain distinct for 100 years, or longer, resembling old shot wounds, Fig. 36. Wounds like these are very common, in some

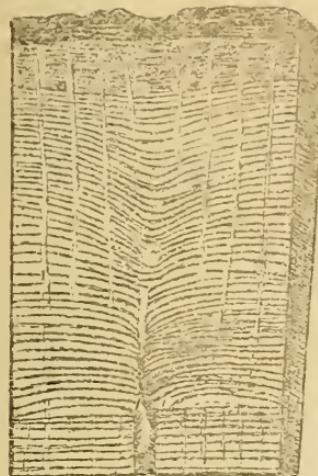


Fig. 35.—Entrance to galleries in Beech forty-four years after the injury was made; showing how the entrance is plugged up by the first and second ears newly forming wood; how the subsequent growths are affected; how all traces are obliterated in the surface of the sapwood, and the original wound remaining in the surface of the outer bark.

localities, in beech bark, where they often mark the deeply buried entrance to an ancient set of galleries.

It is interesting to note the effects in different

woods, resulting from the presence of the injury. In oak, three or four thickened growths form over the entrance, and also over the affected wood, appearing on the end and side of a block as shown in Figs. 37 and 38. These thickened growths extend over the greater

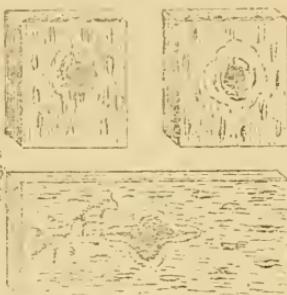


Fig. 36.—Beech Bark, showing wounds fifty to one hundred yrs after the beetles entered it.

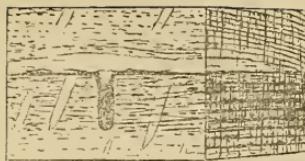


Fig. 37.—*Entrance to galleries in White Oak: covered over by subsequent growths, as they often appear in quarter sawed lumber.* ones extend, also a side view of the stain. When a piece of wood showing this character of a defect is placed in a certain position, the defects resemble somewhat minute steam monitors, the thickened light-colored growths forming the hull, the black gallery the smoke stack, and the curled condition of the wood resembling waves, while the stain represents the back ground and the smoke. I am told that this resemblance to a boat has long been noticed by stave manufacturers, and in fact that the defect is known in certain localities by the term "steamboats," the rule being that if a split or sawn stave contained more than two steamboats, it was reduced to a worthless cull.* Those in Fig. 38, drawn from specimens in our collection are good examples of the so-called steamboat defect in staves, shingles and quarter sawed lumber. This peculiar form of the defect possesses a feature differing from all of the other forms, and that is its liability to split, or crack at the point where the new growths have formed over the stains; thus rendering it, in connection with the holes a serious defect, especially in staves and shingles. The appearance of the two surfaces when thus separated at the entrance is shown in Fig. 39.

The thickened growths as they occur over the stain in yellow poplar, cause a raised surface under the bark for many years after the

*W. I. Protzman, Morgantown.

part of the wood affected by the stain, causing a raised surface which has a depression in the middle. If the split or sawed surface exposes an entrance to a set of galleries, in staves, shingles and quarter sawed lumber, the defect will appear as in

Fig. 38, which shows a portion of the main gallery from which the branching

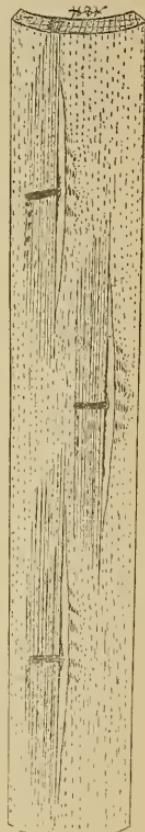


Fig. 38.

A Fig. 39.

B Fig. 39.—*Steamboats in Staves*

Fig. 39.—*Same as 37 and 38 split open, showing at A. the appearance of the entrance; B. the appearance of the under surface of the first year's growth formed over the entrance.*

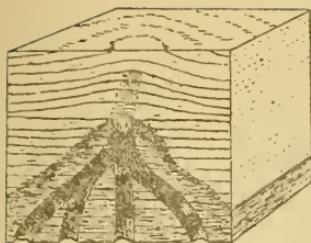


Fig. 40.—*Entrance to galleries in Yellow Poplar;* showing thickened growths over the entrance, and the slightly stained condition of the wood extending a short distance above the entrance.

The injury to the wood resulting from the attack of the beetles, consists both in the black-lined holes, and the stained condition of the wood resulting from the injury. Each of these alone, according to present inspection rules, is considered a defect in the best and medium grades of lumber. Therefore, this insect may be said to cause a double defect in timber. The defects thus caused are found to vary somewhat in character in different kinds of wood, both in regard to the arrangement of the groups of holes, and the extent of the discoloration of the wood, as observed in the sawed and plain surface of a piece of lumber. These differences are due mainly to the greater or less thickness of the sap-wood of the tree from which the lumber is taken, also to the peculiar character of the wood, and its susceptibility to change color on account of a disturbed or unhealthy condition of the sap.

Before referring to the character of injury as appearing in different kinds of wood, I will present some theories regarding the cause of the blackened walls of the galleries, and the accompanying stained condition of the wood.

We can account for the walls of the main galleries and brood chambers being black, but the exact cause of the staining of the wood for an equal distance above and below the injury may not be so easily explained. The galleries being excavated across the fiber of living sap-wood naturally results in the rupturing or separation of a certain number of pores, or ducts through which the sap flows, thus allowing it to escape into the wound. Here it is mixed with the excrements of the developing brood, which, together with the staining qualities in the sap itself when thus escaping, have the effect of coloring the sides or walls of the burrows and brood chambers, in most cases, a deep black. Hence, the application of the name black holes, to distinguish them from pin-holes.

Before attempting to give an explanation of the stained streaks accompanying the black holes, it will, perhaps, be of interest to some of our readers, who are not already familiar with the subject, to give some facts and theories regarding the growth of trees, formation of wood, movement of the sap, etc. It is important to

injury is made. This raised surface, with a distinct depression immediately above the entrance to the galleries, usually extends the full length of the stain that it covers; thus indicating the presence of the injury, until it is covered so deep that the raised surface no longer occurs.

There is a marked difference in the appearance of the stains found in elm, maple, birch, etc.; yet at the same time there is something about the injury that is characteristic of the habits of the species that will enable any one with a little study to recognize them as the work of the Columbian Timber Beetle.

have some knowledge of the subject, not only to better understand the character and interesting features of this peculiar defect, but that the character of insect injuries to wood in general may be better understood.

Formation of Wood

The stem or trunk of a tree is divided into four more or less distinct parts, Fig. 34. Commencing at the outside, we find first the outer or dead bark. Second, the inner or living bark. Third, the sap-wood or living wood. Fourth, the heart-wood or matured wood.

The process of wood formation in our climate, during the life of a tree may be briefly stated as follows:—During the first year's growth from the seed, a ring of bark and wood is formed around a pith. Between the time the leaves fall in autumn and the buds commence to enlarge in the spring, there is a season of rest. Soon after the sap starts to move in the spring, material for another layer of wood commences to form between the bark and the outer portion of the wood formed the previous year. The first portion of the new growth of wood, or ring is found to be more porous and less firm than the outer portion of the ring which forms later in the season when the hardening process takes place, thus causing each ring to appear more or less distinct. The next year another layer, or ring of wood is formed in the same manner, and so on for each year as long as the tree continues to grow, a layer of wood and a layer of bark is formed; the bark beneath and the wood over the growths of the preceding year. At first, or a few years after the first year, only sap-wood is formed, through the pores of which, the water or sap necessary for the nutrition and growth of all parts of the tree is conducted. The amount of sap-wood in each case being apparently in proportion to the amount of sap required by the growing plant, and the capacity of the wood for conducting it. Thus, the wood of a rapidly growing young tree or sapling is all sap-wood and remains so until more wood is formed than is required for the purpose mentioned. At this juncture, it would appear that the sap ceases to flow through the pores of some of the first annual rings around the pith. This portion, being no longer useful to the plant in conducting sap, changes to a dark color. It may then be properly termed matured wood, as the absence of active or crude sap appears to be the cause of its changing to a darker color. This dark or matured wood is called heart-wood, on account of its first appearance around the pith or heart of the tree. The light colored wood beneath the bark is called sap-wood on account of its being that portion of the wood through which the crude sap passes to different parts of the tree. The inner or living bark is also useful in conducting sap and in contributing to the formation of a new growth of wood, which takes place between it and the outer sap-wood. The outer dead bark cracks open as the tree increases in diameter, forming deep fissures, and rough, uneven ridges, or falls off in scales as the outer layers are pushed out by the growth of wood and bark from within.

The sap-wood of the tree appears to be the most vital part of its structure, since the leaves may all be removed, as by insects, at least once during the growing season and other leaves will form the same, or the following season. In fact, at certain times of the year all of the branches may be removed and growth will continue with even greater vigor. A large number of the roots may be severed, as in the process of transplanting, and the tree survive. The heart-wood may all decay, and the tree continue to live and grow. A narrow band of bark may be removed from around the trunk of certain kinds of trees and new bark will form over the wound, and the tree live; yet if only a narrow band of all of the sap-wood be removed from around the trunk at a short distance above the ground, it will soon die. It is true that certain kinds of trees may be killed by simply cutting through the bark around the trunk, but as a rule to kill a tree by the girdling process, either a very wide band of the bark must be removed, or we must cut through all of the sap-wood.

Movement of the Sap in Trees.

One of the theories regarding the movement of the sap in trees is set forth in a general way in the following paragraph quoted from "Practical Forestry" by Andrew S. Fuller:

"All plants obtain their nourishment in a liquid or gaseous form, by imbibition through the cells of the young roots or their fibrils. The fluids and gases thus absorbed, probably mingling with other previously assimilated matter, is carried upward from cell to cell through the alburnum or sap-wood until it reaches the buds, leaves, and smaller twigs, where it is exposed to the air and light, and converted into organizable matter. In this condition, a part goes to aid in the prolongation of the branches, enlargement of the leaves, and formation of the buds, flowers, and fruit, and other portions are gradually spread over the entire surface of the wood, extending downward to the extremities of the roots, * * As the wood and leaves ripen in the autumn, the roots almost cease to imbibe crude sap, and for a while the entire structure appears to part with moisture, and doubtless does so through the exhalations from the ripening leaves, buds, and smaller twigs, but as warm weather approaches and the temperature of the soil increases, the roots again commence to absorb crude sap and force it upward."

The upward movement of the sap in growing trees, it would seem from experiments by Sachs, McNab and Pfitzer, is at the rate of a few inches to several feet per hour. It is believed by some that this upward movement of the sap is caused both by what is termed root pressure and transpiration, or evaporation from the leaves. The following quotations are from "Botany for High Schools and Colleges," by Charles E. Bessey:

"If the root of a vigorous growing plant be cut off near the surface of the ground, and a glass tube attached to its upper end, the water of the root will be forced out, often to a considerable height * * This root pressure appears to be greatest when the evaporation from the

leaves is least; in fact, if the experiment is made while transpiration is very active, there is always for a while a considerable absorption of water by the cut end of the root, due probably to the fact that the cell walls had been to a certain extent robbed of their water by the evaporation from above."

"The flow of water (sap) from the stems and branches of certain trees, notably from the sugar maple, appears to be due to the quick alternate expansion and contraction of the air and other gases in the tissue from the quick changes of temperature. The water is forced out of openings in the stem when the temperature suddenly rises; when the temperature suddenly falls, as at night, there is a suction of water or air into the stem. When the temperature is nearly uniform, whether in winter or summer, there is no flow of sap."

Since it has been found that a dry hot day will cause rapid evaporation of moisture from a plant, which results in a correspondingly increased upward flow of sap, in turn resulting in a tendency by the roots to absorption, it would appear that this tendency of the roots to draw the sap back, is the result of its being taken faster than it can be supplied by them from the soil; consequently, a sudden change from a dry to a moist atmosphere would probably result in a downward movement of the sap through the sap-wood.

It would also appear that the downward movement in the sap-wood may be caused (as in the flow of sap from Sugar Maple) by sudden changes in the temperature and conditions of the atmosphere, as would occur from a hot day followed by a cool night. As it is not the proper place, perhaps, in this connection to discuss at further length the theories regarding the movement of sap in trees, we will proceed to a discussion of the

Causes of Stained Streaks in Wood

The stained streaks in wood resulting from injuries to the living sap-wood of many different kinds of trees are of especial interest, from the fact, that in them evidences are found which appear to confirm certain theories regarding the movement of sap in wood.

This stained condition of the wood may possibly be the result of two causes. *First;* the wound occurring in the healthy wood has the effect of interrupting the natural movement of the sap through that portion of the wood affected by it. This may result in an unnatural, or fermented condition of the sap in and surrounding the ruptured pores, causing it to stain the cells and wood fibres with which it comes in contact. *Second;* a certain amount of the blackened, or discolored fluid occurring in the wound and penetrating the adjoining wood, not only causes the black lining but may extend for some distance into the wood, both laterally and with the grain, until it comes in contact with the active or moving sap. It is then carried with it through the wood until all the coloring or staining elements are taken up by the wood fibres and cell walls. The latter seems most probable from the fact, that it has been often demonstrated by experiment, that coloring matter injected into the wood of

growing plants will be taken up by the moving sap and conveyed through the pores, thereby staining the wood through which it passes.

It is, therefore, easy to understand why the stain extends above the wound and for a short distance on each side, since it is an admitted and well known fact that the sap moves both upward and laterally through the alburnum, or sap-wood; but, if the sap moves only upward through the sap-wood, and the downward movement occurs only in the inner bark, and between this and the outer sap-wood, as we would infer from authoritative writers on botanical questions, the downward extension of the stain would not be so easily explained. This condition of the stained streak is therefore evidence that the theory regarding a downward movement of the sap in the sap-wood is not entirely without foundation; in fact, as most of these stained streaks extend an equal distance above and below the injury, it would indicate that the downward movement of fluid in the sap-wood may be nearly in the same proportion as the upward movement.

Character of the Injury in Oak.

The characteristic form and appearance of the galleries of the Columbian Timber Beetle, as excavated in oak wood, are shown in Figs. 31, 34, 37, 38, 39, and on title page.

In order that the beetles may extend their galleries the desired distance through oak wood, they must proceed to the right or left, soon after they enter the first layers of wood to avoid coming in contact with the heart-wood which appears to be objectionable to them. Thus, a portion of the branching galleries usually extends at right angles to the entrance, and while the brood chambers may extend in any direction, they, as a rule, extend sidewise from the main and branching galleries, Fig. 31. Thus, the injuries occurring in oak, as observed in a piece of sawed or dressed lumber, show from two to eight or more holes arranged in a row directly across the grain of the wood. See title page. The stain accompanying them extends only from two to eight inches above and below the holes. The extent of the stain streaks is usually in proportion to the number of holes. When there is only one hole, the streak will be found narrow, and when a greater number occur, the stain will be broad in proportion.

It will be seen by reference to Figs. 31 and 34 that the appearance of the injuries in a piece of lumber depends largely upon how the piece is sawed from the log. If, as in the usual manner, the log is first squared and all the boards cut from one side, the holes in the middle of all the boards except those near the heart will usually occur in rows, and will not as a rule extend through a board over one inch in thickness. In the edge of the boards, however, and in those from near the heart, the reverse condition will be found; that is, single holes extending through two or three one-inch boards.

In what is known as quarter sawed oak, there is seldom more

than one or two holes in a place, but these may show on both sides of a piece three or four inches in diameter, or in other words, single holes from one gallery may occur in three or four one-inch boards taken successively from the same log. The same galleries would show seven or eight holes in a row in one or possibly both sides of a one inch board sawed in the usual manner, and the adjoining boards would show only a trace of the stain with possibly one or two shallow holes. Thus, by the character and location of the holes in a board or piece of timber, we can usually tell what position the piece occupied in the log.

In staves and shingles which are split, or riven from cuts of logs in the same manner as quarter sawing, one hole may extend through one or two staves, or through a dozen shingles taken successively from one piece, thus rendering them nearly or quite worthless; since the peculiar character and form of the holes make all attempts to plug them unsuccessful. The black holes differ in this respect from pin holes which can be successfully plugged with small wooden pins.

If a living tree affected with black holes is found to be otherwise sound and healthy, which is usually the case, the stained wood surrounding the holes will be just as sound as that adjoining. This is necessarily the case from the fact that the entrance to the holes are sealed up by the new growth soon after they are vacated by the beetles. Hence they are protected from outside influences which would otherwise cause an unsound condition of the wood. If, on the other hand, a tree containing the defects is unsound in any part, the stained wood is liable to be affected by the decay more than that surrounding it.

The stains are also liable to be unsound in the wood of standing dead trees, or of logs and felled trees which have been allowed to lie on the ground more than one year. At least, the stains appear to be more susceptible to decay, in lumber or timber cut from such logs, than from logs recently cut from sound, living trees.

I have found that when the black hole stains occur in sound lumber of good quality, the stains are dark and bright, and that the wood thus affected is as sound as that adjoining them. I have also found that when they occur in lumber from dead trees or old logs, the stains as a rule are light and dull. Heretofore, it has not always been possible to judge whether or not a piece of lumber or timber had been cut from a dead tree, old log or living tree, or whether or not the piece is in a condition to resist decay.

It would therefore appear that we have, in the stains accompanying black holes, another interesting feature regarding this peculiar injury, and one which may be utilized to advantage, namely, an index to the quality of timber and lumber in which they occur. If it is found upon further observations to be the rule that the stains in sound wood of the best quality are dark and bright, and that those occurring in lumber of inferior quality are light and dull, the defects will not be without some redeeming qualities, and would be entitled to a distinctive name. Therefore I will here suggest Co-

lumbian stains as a proper term to distinguish the stained wood accompanying the galleries of the Columbian Timber Beetle from "wind shake" stains, knot stains and discolored sap.

Extent and Distribution of the Trouble in Oak.

As has been previously stated, the defects caused by the presence of black holes in oak wood, are so very common that it is difficult to find any considerable quantity of this lumber which is entirely free from them. Since I have been investigating the subject, I have been surprised to find how extensively wood showing these defects is being used by cabinet makers and carpenters. It is not uncommon to find from ten to twenty of the injuries in a piece of oak furniture. They are frequently observed in wainscoting and other natural wood finishes where oak is used. They are common in oak flooring, joists, and square timber; in wood used in the construction of railroad trestling, bridges, etc. In a railroad trestling of considerable length recently examined, scarcely a piece of timber could be found that did not show more than one of the defects, and in some of the main posts nearly 100 separate groups of the holes were counted. They are also common in railroad ties, and immense quantities of timber are lost in the manufacture of staves, shingles, etc., on account of the holes which are exceedingly objectionable defects in material of this character.

It appears that the timber from certain localities, and exposures, is affected by this trouble more than it is in others. It would also appear from what I have learned by inquiry, and from my own observation, that the difference in the amount of timber affected on an east and west exposure is quite marked; timber from the latter being often seriously injured, while that from the former is almost, or quite free from injury. It also appears that timber in the valleys is affected more than that on the tops of the hills and mountains.

In regard to the distribution of this trouble in the United States, I have little means of judging. I have, however, observed the defects in lumber from Michigan, which would indicate that the insect is not confined to any restricted locality.

Estimated Losses From the Defects in Oak.

According to the inspection rules governing the grading of hard-wood timber and lumber having a commercial value, the black holes and stains are considered defects not allowable in the higher priced grades. Therefore when they occur in a piece of lumber or timber, its value is reduced on this account at the rate of 85 to 820 per thousand feet. As a rule these defects occur in wood having no other defect, or in lumber which would otherwise be placed in first and second grades. Thus, one million feet of lumber reduced to lower grades (commons and culls) would on this account represent a depreciated value of at least \$10,000 below the selling price of first and second grades. It has been estimated by good authority that 50

to 75% of the White and Chestnut Oak, in certain localities, is more or less affected with this trouble.

The expense of handling, shipping and marketing the lower grade is just as much as if the material was of the higher grade; therefore there must be serious loss on account of this trouble, sustained by some one during the process from the standing timber until the lumber reaches the consumer: the greatest loss being evidently sustained by the owners of the timber and the manufacturers of timber products.

Methods of Preventing Loss.

When we come to consider methods of preventing loss from the insect injuries we have been discussing, we are met with a number of difficulties not found with injuries ordinarily caused by insects. In the first place, the injuries by the Columbian Timber Beetle, and especially those causing the greatest loss, were caused from 50 to 300 years ago; hence, it is an injury to deal with, the nature of which permits only of the use of expedient methods. Therefore, in order to avoid loss on its account, we must resort to methods of utilizing to the best advantage the affected material.

Suggestions for the Utilization of Affected Material.

The extent to which a given defect will damage or reduce the value of a piece of lumber depends largely upon what the piece is intended for, or to what use it is best adapted. A defect in a piece of lumber manufactured for certain uses may reduce its value to that of a mill cull, while the same thing in a piece intended for certain other uses would not be considered defects even in the best grades, because it would not be a detriment to the manufactured article in which the piece is to be used. Therefore, while the black holes and Columbian stains may be defects in lumber intended for one purpose, they may not be so in lumber intended for some other purpose, and possibly may be even desirable in material required for some of the many and varied articles manufactured from oak wood.

Considering the subject from this standpoint, it appears to us that all of the oak timber, in which the black holes and stains are the only defects, could be manufactured into material that would not be depreciated in value on this account much, if any, below that of first and second grades.

As has been demonstrated, the black holes more often occur in the best and soundest wood of a tree, and the stained wood resulting from this injury is usually just as sound as the wood adjoining it; therefore, if the same care is exercised in handling lumber affected with black holes, as is done with clear lumber to prevent damage from blueing, etc., the Columbian stains will remain sound, and would not be any more of a detriment, and in many cases less so than clear sap. Clear sap being allowable in first and second grades, especially in material to be used for inside work and in arti-

cles to be varnished and painted, there is no real reason why black holes and bright Colombian stains should not, to a certain extent, be allowed in the better grades of lumber intended for like uses.

If it could be clearly demonstrated that the black holes are not detriments to lumber intended for certain uses, requiring best and high priced grades, and rules should be adopted by the hard-wood lumber associations, allowing them in the best grades of certain specified material, it would add very considerably to the income of owners of oak timber, and to the profits of the manufacturers of lumber from the same, and no one, if the lumber was utilized for the purpose intended, would be the loser. As a rule, whatever adds to the value or selling price of a natural product, adds just so much to the prosperity of the region or state having a large amount of the same. Therefore, the question of how to prevent depreciation in value of lumber manufactured from affected timber is an important one, worthy of careful consideration.

If information could be had, through discussions at meetings of Lumber associations, from experts in the different uses of oak lumber, and from consumers regarding the several kinds of articles and work in which such lumber could be used without detriment; then a list of such uses, with dimensions of the lumber suitable for the same, could be published in a bulletin of this kind, or in timber journals. The information gained would thus be available for owners of timber and manufacturers of lumber, and the affected timber could be manufactured into dimensions suitable for some of the specified uses.

Means of Detecting Affected Trees and Logs.

During the investigation, I have discovered some means of detecting trees that are affected with black holes and stains, and for indicating the extent of the trouble in freshly cut logs. It was found that the bark of trees attacked last spring and summer showed dark, wet stains extending one to four or more inches below the hole in the bark where the insect entered. These stained spots can often be seen when the observer is a considerable distance from the tree. If there are many of them visible on a tree, we may safely conclude that the wood throughout is more or less affected with the trouble, since it appears that a given tree may be the host of generation after generation of the beetle, and that once the tree is attacked, successive broods may continue to utilize it for the perpetuation of their species. This is not the universal rule, since, on account of the scarcity of the insects some years, trees previously attacked will not show any outward indications.

There is another, and perhaps more reliable means of detecting affected timber, and that is to examine the ends of the logs directly after they are sawn off, when, if the logs are affected to any great extent, a number of the stained spots, (the ends of the stained streaks) will show on the freshly cut surface as in Fig. 34. If there are many of these stained spots in the end of a log, it is a sure indi-

cation that the log is badly affected with them throughout. Before such logs reach the saw mill, however, the stained spots will be obliterated by the action of the weather, dirt, etc. Therefore, if such logs were branded, as they are cut, with some peculiar mark, it would indicate to the sawyer at the mill, the character of the log and the kind of lumber to be expected from it. Thus, trees indicating the presence of the defects, by the stained spots on the bark, could be cut into logs suitable for certain desired dimensions, and the branded logs could be utilized to the best advantage with very little additional expense.

Suggestions Regarding Proper and Improper Uses of Columbian Lumber.

The different grades of lumber designated in inspection rules, are referred to by some distinctive name; therefore, in order to distinguish lumber and timber having no other defects than black holes and Columbian stains, I would suggest the name Columbian, to be applied to a grade which would include lumber and timber of all kinds and dimensions, in which black holes, and bright sound stains are the only defects.

It is evident that while there are certain kinds of structures and articles, which will properly admit of the use of Columbian lumber, there are other purposes for which such lumber should never be used.

Columbian Oak should not be used in articles requiring wood of special strength, as in wagons, agricultural implements, and in important timbers in buildings, bridges, trestling, etc. It should not be used to any great extent in structures, or articles which are to be exposed to the weather, unless thoroughly protected by paint, or with other substances which would prevent the holes and stains from absorbing and retaining moisture. It appears, however, that if a piece of timber is tough and otherwise of the best quality, it may contain many of the holes and stains, and yet withstand the action of the weather, unprotected by paint, longer than some of the unaffected pieces, especially if the latter are of a brash and inferior quality. In fact, I have observed certain posts in an old railway trestling in which the stains were perfectly sound, while in other posts they were in an advanced stage of decay. Thus, it will be seen that if the Columbian timber is to be used at all in such structures, good judgment should be exercised in its selection, and only those pieces indicating that the wood is of the best quality, and most capable of resisting decay, should be used.

Oak wood containing light colored or unsound stains should not be used for joists, sills and like material, which are to be placed where the conditions will favor "dry rot," nor in any important structure requiring strong and durable timber, or in structures, the wood-work of which is exposed to the weather, unless thoroughly painted, and even then such timber is liable to premature decay on account of the unsound stains beneath the surface.

Columbian heading, shingles, staves and like material are as a rule to be considered worthless culls, or at best low grade material, since the holes cannot be successfully plugged, and staves containing them are liable to split when bent.

There are a great many uses requiring only second and low grade lumber and timber in which Columbian lumber may be properly used and for which it is now being extensively utilized. In truth, a large amount of otherwise first-class timber is annually being manufactured into low priced material suitable for such uses.

It is not of the common uses admitting of cheap grade material to which I wish to call attention, but to uses requiring high priced grades, which will properly admit of Columbian lumber without detriment to the finished articles.

It may be of interest to owners of timber, manufacturers of lumber and dealers in the same to know, that an immense amount of Columbian lumber is daily being used in structures, and manufactured articles, which are supposed to contain the higher priced grades. In order for any one to satisfy himself on this point, he has only to look around him a little, and will no doubt be surprised to find the remarkably common occurrence of the holes and stains in oak furniture, natural wood finish and wooden structures, and that there is in reality very little prejudice or objection to the so-called defects, expressed by purchasers and owners of finished work. In fact, I agree with carpenters and cabinet makers, with whom I have frequently discussed the subject, that the stains give a certain variety, and antique appearance to the wood, together with an indication of its genuine character and quality, which is really desirable and to be admired. I should not be at all surprised if in the near future there would be a demand for this grade of lumber on account of a freak of fashion in furniture and natural wood finish, which would demand the presence of some of the Columbian stains in every piece.

Since the owners of timber suffer serious loss from the depreciation in value of their timber and lumber on account of the so-called defects, and since the purchasers and owners of finished articles manufactured from wood, allow, without complaint, the extensive use of such material in expensive work, it appears that the owners of timber and the manufacturers of timber products should derive some benefit from this state of affairs, which would result in the enhancement of one of our important natural products.

Character of the Injuries in Yellow Poplar.

Oct. 12th to 13th and Dec. 30th, '93, to Jan. 1st, '94, were spent in a poplar lumber region in this State for the purpose of investigating a peculiar defect locally known as "Calico Poplar," which was found to be caused by this Columbian Timber Beetle. In this wood, the stains instead of extending only a few inches above and below the holes, as in oak, often extend several feet in both directions. When the defects occur at all frequently in a poplar tree, the

extended stained streaks run together, which often results in a beautiful combination of colored wood, such as black, brown, purple, blue, etc. See Plate II. Since this condition occurs in the most valuable part of the tree, the wood so affected is rendered unmerchantable, or at least in commercial value, greatly reduced. The illustration will give an idea of the appearance of lumber affected in this way, after it is dressed and arranged in a panel. It will be seen that the effect is very striking. The photograph, however, does not convey an idea of the colors.

The conditions appear to be more favorable for the development of the beetle in this wood than in the other kinds of wood infested by it. The branching galleries are found to be more numerous, and the brood chambers to occur, as a rule, in greater numbers. The form of the galleries as occurring in this wood, is shown in Fig. 41. The side or brood chambers almost invariably extend up and down from the branching galleries.

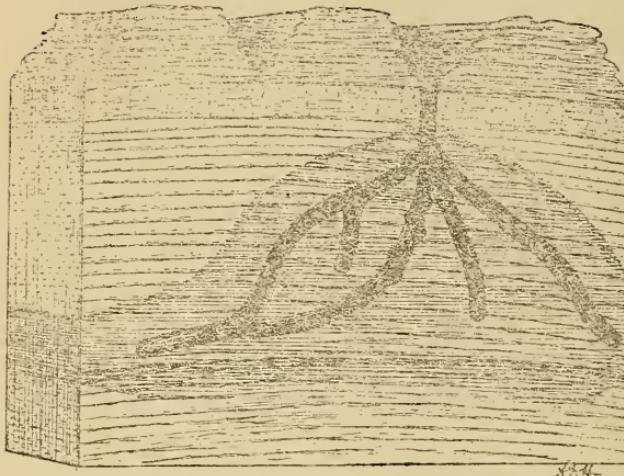


Fig. 41.—Character of galleries in Yellow Poplar.

ies; hence the holes, as they appear in the surface of a piece of lumber differ from those observed in oak, in that there are seldom over four holes in one place and that often full length brood chambers will appear as in Fig. 42.

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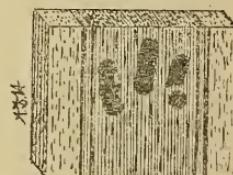


Fig. 42.—*Brood chambers as they appear in Poplar and Beech.*

PLATE II.



W. E. Rumsey Photo,
COLUMBIAN POPLAR---Five Boards 1-2 Ft. X 5 Feet.

The sap-wood of Yellow Poplar being usually not over one or two inches thick, the holes from one set of galleries do not extend very far in any direction; hence, do not show on both sides of a plank over two inches thick.

The great distance to which the stains extend above and below the holes, is a very marked characteristic in this wood, making it easy to judge if a freshly cut log is much affected by the trouble, since if very many of the stains occur in a log, say 16 ft. long, both ends will show numerous dark spots as in Fig. 34.

Distribution and Losses

I have not as yet been able to satisfactorily ascertain the extent to which the trouble exists in the several poplar regions of the State, but from my observation, and from what I can learn, it appears to be confined to certain restricted localities and exposures. In such localities the depreciated value of the products from the affected timber has been such as to cause the receipts to fall below the cost of production; hence, in some cases it has been found best to allow the timber to stand, rather than attempt to convert it into lumber.

It would appear that the depreciation in value is due more to prejudice than to any real detriment to the lumber. The stains most frequently occur in the choicest part of the tree, and in lumber which would otherwise pass as first-class. The stained portion, as a rule, is just as sound as the unaffected wood; yet boards affected as those illustrated in the plate are reduced in value, on this account, from No. 1 grade to a mill cull, or at the rate of \$15 to \$20 per thousand feet.

Utilization of Columbian Poplar.

Whether or not Columbian Poplar could be utilized in the same manner as Columbian Oak and with as pleasing effects, I will leave my readers to judge. I have had some of this Columbian (Calico) Poplar prepared both in stained and natural wood finish, the effect being both interesting and attractive, and it seems to me that the apparently limited quantity of poplar timber, affected in this manner, could be utilized without having its value depreciated much below that of first and second grades.

Remedies.

The injury caused by the Columbian Timber Beetle is a peculiar one, differing from those ordinarily caused by destructive insects in so much that a remedy for the trouble, so far as benefitting this generation, is not to be found in methods of destroying the insects or preventives against its attack. This is evident from the fact that the defects as observed in lumber and timber are some of them centuries old, and all of them occurring in heart-wood were excavated at least forty or fifty years ago. It is also evident that if all the Col-

umbian Timber Beetles were destroyed now, the present generation would not derive much benefit from their extinction, from the fact that injuries caused by them this year will scarcely be out of the sap-wood fifty years hence. Therefore, it seems more proper that we should look to methods of utilizing to the best advantage the defective timber and lumber and to treatment of the affected wood to prevent premature decay. As we have already discussed the former methods, I will offer only a few suggestions regarding the treatment of the stains and holes, the object being to either protect them from catching and retaining moisture, or to counteract their detrimental appearance. As a protection there is nothing, perhaps, better to use than linseed oil, paint, coal tar, etc., which if applied to stains that are not perfectly sound, will tend to preserve and protect that portion of the wood from unnatural moisture and premature decay. As a filter, there is nothing better, perhaps, than putty with which to fill the holes. There is one mistake with regard to the use of the putty, for this purpose to which I desire to call attention, and that is instead of staining it the color of the natural wood, or using it without coloring, as is the common practice, it should be colored to correspond with the stain surrounding the holes.

Natural Enemies of the Beetle.

No very accurate information regarding the natural enemies of this insect has yet been determined. I have found, however, during the investigation, that a large per cent. of the hundreds of galleries examined, in which broods of beetles developed last summer, were occupied by a small white maggot, Fig. 43, and in no case were live beetles or young found in the galleries thus infested. On one or two occasions, I found some of these maggots within the dead bodies of beetles, but whether or not it is a true enemy of the beetle, or merely inhabits the vacated galleries to feed upon the escaping sap, and dead beetles, I would not say.



Figure 43.—*Maggot, or fly larva, from galleries of Columbian Timber Beetle* greatly enlarged.

There are numerous other predaceous insects, however, which would likely attack it both in and out of its galleries, but to what extent these species reduce its numbers or prevent its increase, has not been determined.

The European Bark Beetle Destroyer, which we have been introducing from Germany as an experiment, with reference to the ravages of bark beetles in the pine and spruce forests, would readily attack and devour the adults of the Columbian Timber Beetle if they met with them. It is not probable, however, that they would seek for them on oak and other deciduous trees to a sufficient extent to render much benefit, since this European insect is more inclined to feed upon the bark beetles which inhabit the pine and spruce.

Conclusions.

In concluding this account of a common insect injury to wood, I may say that the investigation has proven a most interesting one, regarding which there is yet much to learn, and much that is suggestive of the importance of a better knowledge of all common things around us. In fact, one of the objects of this bulletin is to call the attention of our readers to the necessity of a more critical observation of the annoying, destructive, beneficial and mysterious elements of nature.

Common objects, the nature of which, little if anything is known, may be of no interest to the general observer from the very fact that they are common, and that nothing interesting or pleasing is known about them. If it is a thing that causes trouble or loss of time and property, it is natural for persons to fail to see anything pleasing or attractive, even when it is demonstrated that it has some interesting features, but on the other hand, let it be shown that the object has a commercial value, and opinion will soon change.

May not the conditions resulting from the attack of the Columbian Timber Beetle prove to be an example of this kind? The injuries are of such frequent occurrence in different kinds of common wood that they are not noticed by persons who are in no way affected by them. They have heretofore been looked upon as nothing but worm holes, supposed to be attended by streaks of unsound wood. Dealers in timber products, however, object to discolored wood and insect injuries, especially when making a purchase, claiming that they are all defects which must depreciate the value of the material. Owners and producers must dispose of such products at a reduced price; hence are necessarily prejudiced against defects, thus affecting the receipts from their investments. That there are numerous interesting features with reference to the Columbian Timber Beetle, and the conditions resulting from its breeding in living sapwood is evident. That the presence of the so-called defects is not always detrimental but on the contrary of economic importance is equally evident. Therefore, with our present knowledge of the subject, shall we think it improbable that instead of being considered defects, they may, as seen in natural wood finish, serve as pleasing objects to draw our attention to nature and her handiwork?

